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Children's Understanding of Spoken and Visual Ambiguity

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Abstract

Sodian (1988) found that it was not until about age 5 that children begin to understand that a spoken message restricts knowledge. In contrast, Ruffman, Olson, & Astington (1989) found that children begin to understand that visual ambiguity restricts knowledge around age 4. The present study was carried out with forty 4-year-olds to determine whether children's understanding of spoken and visual ambiguity is parallel. In the spoken conditions, Ss were asked to assess the knowledge of a doll who was given either an ambiguous or unambiguous message regarding the contents of a box. In the visual conditions, Ss were asked to assess the knowledge of a doll who was presented with either visually ambiguous or unambiguous stimuli. It was found that children tended to either pass both the spoken and visual ambiguity tasks or fail both, rather than passing one but not the other ($p < .01$). It is argued that the underlying recognition at this age is that the perceptual information available is sometimes an insufficient source of knowledge, and that this recognition is tied to the capacity for metarepresentation and is fundamental to children's understanding of ambiguity, false belief, appearance-reality, Level 2 perspective-taking, and representational change.

Children's Understanding of Visual and Spoken Ambiguity: Theoretical Implications for a Developing Theory of Mind

Research has shown that between the ages of 2 and 6, children undergo tremendous growth in their understanding of their own and others' minds, and that age 4 to 5 is a particularly important period. A recent study by Ruffman, Olson, & Astington (1989), shows that one accomplishment at this time is that children begin to recognize visually ambiguous perceptual information as an insufficient source of knowledge.

In that study there were two conditions in which children's understanding of ambiguity was assessed. In the same perspective condition a *subject* and an *other* (a doll) were shown two same-colored animals (a grey elephant and a grey rabbit). These animals were then placed separately in two identical cardboard boxes each of which had a small hole in the center which allowed a viewer to see the object's color but not its shape. Neither the subject nor the other saw which animal was placed in which box so that the visual cues (two grey patches) available to both subject and other were ambiguous. The procedure for the opposite perspective condition was identical except that in this case the subject watched the experimenter place the animals in the boxes but the other did not. Thus, while the visual cues (two grey patches) were ambiguous to both, the subject had grounds for knowing which animal was in which box (by virtue of memory) but the other did not. In a control condition two different-colored animals (a green turtle and a brown chicken) were used. As in the opposite perspective condition the subject but not the other, watched while the animals were placed separately in cardboard boxes. However, in this condition the visual cues (a green patch and a brown patch) were unambiguous to both subject and other so that each had grounds for knowing which animal was in each box.

Children who failed the control condition by incorrectly claiming the other would not know which animal was in which box when the cues were unambiguous, were excluded from further analysis. It was found that very few 3-

year-olds, just over half the 4-year-olds, and almost all 5- and 6-year-olds correctly claimed that the other would not know which box the elephant was in over both the same and opposite perspective conditions. These results suggest that 4 is the transitional age in children's understanding that visually ambiguous perceptual cues restrict another's knowledge.

Sodian (1988) has also studied children's understanding of ambiguity, in this case an ambiguous message (spoken ambiguity), and did so using both a same and opposite perspective condition. In the former, subjects were asked to judge the knowledge of a listener doll who like the subject, had not seen which of three drawers an object had been placed in. A speaker doll then gave the subject and listener an ambiguous message regarding the location of the hidden object. This procedure was repeated until two ambiguous and two unambiguous messages had been given. The procedure for the opposite perspective condition was identical except that, here, the subject always saw which drawer the object had been placed in, and so, always knew where the chocolate was regardless of the speaker's message.

As in the Ruffman et al. study (1989), only those children who passed the control condition by correctly claiming that the listener knew which drawer the chocolate was in when the message was unambiguous were considered in the analysis. Sodian found that in both the same and opposite perspective conditions almost all 6-year-olds correctly judged that the listener would not know which drawer the chocolate was in when the message was ambiguous. In the 4-year-old group, 27% made a similar correct judgment in the opposite perspective condition and 64% did so in the same perspective condition.

These results are roughly comparable to those obtained by Ruffman et al. (1989) in that almost all 6-year-olds, but a smaller percentage of 4-year-olds were correct when assessing the other's knowledge. However, there is an important difference between the results of the two studies, the significance of which can only be understood by describing the demands placed on subjects in the same and

opposite perspective. The opposite perspective condition is a more stringent test of children's understanding of ambiguity because it requires children to recognize that the other lacks knowledge to which they are privy. Indeed, Sodian (1988) suggests that in the opposite perspective condition, when children cannot rely on their own feelings of certainty or uncertainty, incorrect performance indicates that assessments of another's knowledge are based solely on the presence or absence of informational access without an understanding that this access is sometimes an insufficient source of information.

Children in Ruffman et al.'s study correctly judged the other's knowledge state regardless of perspective; 58% of the transitional 4-year-old group were correct in the opposite perspective condition while 74% were correct in the same perspective condition. Over all age groups, performance on the same and opposite perspective conditions was very similar; while the 3- and 5-year-olds did slightly better in the opposite perspective conditions, the 4- and 6-year-olds did slightly better in the same perspective conditions.

As stated above, the 4-year-olds in Sodian's study made more errors when assessing the other's knowledge in the opposite perspective condition than in the same perspective condition. In fact, in the opposite perspective condition, the 4-year-olds in Sodian's study performed at a level (27% correct) that was closer to that of the 3-year-olds of Ruffman et al. (26% correct). This result is somewhat puzzling. An understanding of visual and spoken ambiguity require a similar insight, namely, that perceptual information is sometimes an insufficient source of knowledge. That is, children must recognize that though the other has seen an object or has been told of its location, the perceptual information available (the ambiguous portion of the object visible or the ambiguous nature of the utterance) does not permit knowledge of the object's identity or location. Thus, one could expect that children come to understand both at about the same time.

There are other reasons for suspecting that children come to understand spoken and visual ambiguity around age 4. First, this is the age at which

children come to understand false belief (Perner, Leekham & Wimmer, 1987; Wimmer & Perner, 1983), and like ambiguity, an understanding of false belief also requires children to recognize that the perceptual information available is sometimes an insufficient source of knowledge. For instance, in false belief children must recognize that the other has seen only that an object was placed at location *X*, has not seen it moved to *Y*, and therefore doesn't know it is at *Y*. How is this accomplished and what insights are needed for such an understanding? Perner (1988) argues that the significance of recognizing false beliefs lies in the fact that in doing so, children create mental models (representations) which are independent from their model of the real world. By separating beliefs from the real world children are then able to (meta)represent another's representations.

Likewise, an understanding of ambiguity also requires an understanding of metarepresentation. A number of authors (Forguson & Gopnik, 1988; Flavell, 1988; Taylor, 1988; Wellman, 1988) have suggested that what children must recognize is that the other *interprets* incoming perceptual information. Chandler (1988) calls this a *constructivist* theory of mind. This recognition is best illustrated by contrasting children's understanding of ambiguity with their understanding of inference as sources of knowledge. Inference (Sodian & Wimmer, 1987) and ambiguity (Chandler & Helm, 1984; Olson & Astington, 1987; Ruffman & Olson, 1989; Taylor, 1988) tasks both present children with situations in which they must judge another's knowledge state based on the other's access to incomplete perceptual information.[1] Yet, whereas in the former they must recognize that one will come to know (through inference), in the latter they must recognize that knowledge is not possible. This understanding - which is not possible unless children can model the process of knowledge acquisition, that is, have a conceptual understanding of how the available perceptual information results in knowledge or a lack of knowledge - is metarepresentational.

The idea that an understanding of ambiguity requires a capacity for metarepresentation can be illustrated in another way. Consider, for instance, the

ambiguity task employed by Ruffman et al. (1989). Recall that in this task two same-colored animals (an elephant and a rabbit) were introduced to a child and an other (a doll), and were then secretly placed in two boxes such that only a small ambiguous portion was visible through a hole in the center of each box. Children were required to recognize that because the other had not seen which animal was put in which box, she would not know which animal was which. Of course the reason the other would not know is that she could represent each animal as either an elephant or a rabbit. As Flavell (1988) points out, such a recognition is, in fact, very similar to the insight needed in appearance-reality tasks (Flavell, Green & Flavell, 1986) and Level 2 perspective-taking tasks (Flavell, Everett, Croft, & Flavell, 1981), where again children must recognize that the same stimulus may be represented in two different ways.

In sum, then, ambiguity and false belief tasks (and for that matter inference tasks) require the same fundamental insight; children must have the capacity for metarepresentation. Hence, we are left with the question of why past research has indicated that an understanding of ambiguity and inference, acquired around age 6 to 7, are (relatively speaking) such late achievements.

One possibility is that the perceptual cues which include the key information upon which subjects' judgments of the other's knowledge rests, are much more salient in false belief tasks than in ambiguity and inference tasks. That is, in the typical false belief task the other's not seeing the object moved from the original location is a very clear cue that the other has not had access to key information. On the other hand, past research involving children's understanding of ambiguity and inference has not placed nearly as much emphasis on the salience of perceptual cues. Part of the problem lies in the nature of ambiguity and inference where unlike false belief, perceptual information is not presented in an all-or-nothing format. Consider, for instance, Sodian's (1988) spoken ambiguity task where the perceptual cues were much more subtle. As in a false belief task children were required to realize that the other's not seeing an

object placed in a drawer limits her knowledge. However, unlike false belief, the other is then given access to perceptual information - she is informed, albeit ambiguously ("The object is in the red drawer"), of the object's location. This second source of information could understandably confuse children when judging the other's knowledge unless all relevant information is made very clear to them (eg. that there are two red drawers). Recognizing that the other will not know which drawer the object is in without such clarification is consequently more difficult than arriving at the same recognition in a false belief task.

Thus, it is possible that by increasing the salience of key perceptual cues, children would be given the opportunity to demonstrate their understanding of the way in which incomplete perceptual information effects knowledge. Indeed, the study of Ruffman et al. (1989) used such a procedure to show that children understand visual ambiguity earlier than had previously been thought. To this end, prompts and reminder questions can be included to help children keep track of relevant details and recognize that though the other has had access to perceptual information, this information is not always sufficiently informative.

The purpose of the present study was to determine whether visual and spoken ambiguity are facets of the same underlying understanding, and in so doing, to determine whether children begin to understand spoken ambiguity around age 4. In order to test this hypothesis it is necessary to give children who are in the transitional stage tasks measuring their understanding of both spoken and visual ambiguity. Testing children who are younger or older would not yield a great deal of information because these children are much more likely to either fail or pass both tasks. Given that the results of Ruffman et al. (1989) suggest 4 is the transitional age in children's understanding of ambiguity, it was decided that only 4-year-olds would be included as subjects in the present study. If visual and spoken ambiguity are facets of the same underlying understanding, then children should either pass both the visual and spoken ambiguity tasks (using a simplified version of Sodian's (1988) task where perceptual cues are made more salient) or they should fail both, rather than passing one but not the other.

Spoken and Visual Ambiguity

Method

Subjects

Subjects included forty 4-year-old children who attended metropolitan day cares or junior kindergarten. The mean age was 4;6 (range 4;1 to 4;11).

Materials

There were four conditions; two spoken and two visual. Three same-sized cupboards (11 cm. high x 7 cm. wide x 2.5 cm. deep) were used in the spoken conditions. Two cupboards were red and one was green. Thus, utterances referring to the green cupboard were unambiguous while those referring to the red cupboard were ambiguous. A chocolate was hidden in one of the cupboards by a speaker doll (Katy), while a second doll (John) was listener. Each doll was 38 cm. tall. A cardboard screen (195 cm. long x 85 cm. high) was used as the partition which divided the experimental area from the "playground". The two dolls and screen were also used in the two visual conditions along with two pairs of animals; the ambiguous pair (a grey elephant and grey rabbit), and the unambiguous pair (a brown chicken and green turtle). The two animals from each pair were placed separately in cardboard boxes that were 14 cm. long x 14 cm. wide x 5 cm. deep. Each box had a 2 x 3 cm. hole cut in the center which enabled a viewer to see the animal's color but not the shape.

Procedure and Design

Each child received all four conditions. One spoken condition measured children's understanding of an unambiguous message while the other measured their understanding of an ambiguous message. Similarly, one visual condition involved stimuli that were unambiguous while the other involved stimuli that were ambiguous. The conditions in which unambiguous stimuli were present

acted as controls; in order for children's assessments of the other's knowledge in the ambiguous conditions to be meaningful, they must recognize that unambiguous stimuli will lead to knowledge. The two spoken conditions were always given contiguously, as were the two visual conditions. The order of the two conditions (ambiguous and unambiguous) within the visual and spoken pair were counterbalanced as were the order in which children received the visual and spoken pair. Within each of the four conditions there was a *self* series of questions and an *other* series. In the self series the subject was asked to assess his or her own knowledge, and in the other series the subject was asked to assess the knowledge of the other (John). The order of the two series was also counterbalanced.

Children were taken individually to a quiet area. The child sat at one end of a table, the two dolls at the other, and the experimenter in the middle. First, the dolls were introduced to the subject as "other persons, just like you or me". In the visual conditions children were shown the two animals from either the ambiguous or the unambiguous pair, and were asked what John would say each animal was and whether they were the same or different colors. Children were corrected if they answered either question incorrectly. John then went out to the playground and in his absence, Katy put the two animals in separate boxes. At this point, subjects were asked two reminder questions; "Which box did Katy put the elephant (chicken) in?", and "Did John see which box she put it in?", and again, were corrected if they answered either question incorrectly.

When he returned, John looked through the box holes at each animal. In order to clarify the significance of this action the experimenter pointed to the boxes and said, "Now, John looked through the box holes at the animals. And when he looked he saw a part of the animal, didn't he? He saw the middle part. And when he looked at the middle part what did he see?". If subjects responded with an answer which did not refer to the color of the animals the experimenter said, "He saw the color of the animals didn't he?", and then asked subjects, "And

will John say these animals are the same or different colors?". The experimenter then said, "So, John saw the color of the animals and these animals are the same (different) color(s)". Subjects were corrected if they answered the same-different question incorrectly.

The subject was then asked the self and other series of questions (see Table 1). However, before being asked whether John knew which box the elephant (chicken) was in the experimenter gave subjects a final reminder of the pertinent details: "Now remember, did John see which box Katy put the elephant in?" - Right. And John will say these animals are different colors won't he? He knows the turtle is green and the chicken is brown. (Right. And John will say these animals are the same color won't he? They're both grey.)". Subjects were corrected if they answered the *see* question incorrectly.

Insert Table 1 about here

Prior to receiving the spoken conditions children were shown the three cupboards and asked how many were red and how many were green, and were corrected if they answered either question incorrectly. They were also shown John's chocolate which was placed in front of the open cupboards. Next, John went out to the playground (behind the cardboard screen) and while he was there Katy put the chocolate in one of the cupboards. The cupboards were arranged with a green and red cupboard adjacent to each other, and the second red cupboard on top. In the unambiguous condition, Katy placed the chocolate in the green cupboard and in the ambiguous condition Katy placed the chocolate in the bottom red cupboard.

At this point, subjects were asked two reminder questions; "Which cupboard did Katy put the chocolate in?", and "Did John see which cupboard she put it in?", and were corrected if they answered either question incorrectly. Reminder questions were included in order to make the relevant perceptual cues

as salient as possible and thereby simplify Sodian's (1988) original task as much as possible. Later, when John returned from the playground he asked Katy, "Where did you put my chocolate?". In the unambiguous condition Katy replied, "The chocolate is in the green cupboard", and in the ambiguous condition she replied, "The chocolate is in the red cupboard". The experimenter repeated the speaker's message once more for emphasis.

The self and other question series then followed (see Table 1). However, before being asked whether John knew which cupboard the chocolate was in the experimenter gave subjects the following final reminders of the pertinent details: "Now remember, did John see which cupboard Katy put the chocolate in?" - "And how may green (red) cupboards are there?" - "So, Katy said, 'The chocolate is in the green (red) cupboard', and there's only one green cupboard (and there's two red cupboards)". Subjects were corrected if they answered either question incorrectly.

Results and Discussion

There were no significant effects for the order of condition (ambiguous vs. unambiguous, or spoken conditions vs. visual conditions), or the order of *self* and *other* questions. Nor were there any significant sex differences.

While the majority of children answered the reminder questions correctly, some did not. In the visual conditions, eight children (20%) responded incorrectly on at least 1 of 4 questions when asked if the animals were the same or different colors. These children did not appear to have learned the meaning of same and different. The reminder question in which subjects were asked if John had seen which box Katy put the elephant (or chocolate) in was answered incorrectly on at least 1 of 8 trials by six children over both the visual and spoken conditions. In the spoken conditions the question regarding the number of green and red cupboards was answered incorrectly on at least 1 of 4 trials by one child. While

failures on these questions may have reduced the likelihood of correct responding in the control and experimental conditions, these children were not excluded from the following analysis.

Eight children failed the visual or spoken control condition by incorrectly claiming either that the other did not know which box the chicken was in when the visual cues were unambiguous, or by incorrectly claiming that the other did not know which cupboard the chocolate was in when the message was unambiguous. These children were excluded from further analysis. The remaining sample consisted of 32 children with a mean age of 4;6 (range 4;1 to 4;11).

All children assessed their own knowledge perfectly; they always correctly claimed to know which box the elephant was in, or which cupboard the chocolate was in. The main question tested by this study was whether the onset of children's understanding of spoken and visual ambiguity is parallel. In order to determine this we must look at children's assessments of the other's knowledge and consider the number of children who having passed the control condition, either passed both the spoken and visual ambiguous conditions or failed both, relative to the number of children who passed one ambiguous condition but not the other. In this study there were 28 children who fell into the former category while only 4 passed one ambiguous condition but not the other. This pattern differed significantly from chance [$X^2_{(1,\ N\ =\ 32)} = 10.47$, $p < .01$]. The relation between the two tasks is shown in Table 2.

Insert Table 2 about here

The above pattern suggests that children did better on the modified version of Sodian's (1988) spoken ambiguity task which was used in the present experiment than did the children in Sodian's original study. This was, in fact, the case. Recall that only 27% (3 of 11) of Sodian's subjects responded correctly in the opposite perspective condition when given an ambiguous message. In comparison,

59% (19 of 32) responded correctly on this condition in the present study. This figure is much higher than that obtained by Sodian, and is comparable to children's performance on the visual ambiguous condition where 66% (21 of 32) correctly assessed the other's knowledge.

Again, there are two possible reasons why the 4-year-olds in our study performed better on the opposite perspective condition than those in Sodian's study. First, it is possible that because children in our study were required to assess the other's knowledge fewer times than children in Sodian's study, fewer errors were made. While there was only one ambiguous message in the opposite perspective condition in the present study, there were two ambiguous messages and subsequent knowledge assessments required in the opposite perspective of Sodian's study. However, the percentage of subjects passing both ambiguous conditions of the present study was very similar to the percentage passing either ambiguous condition (spoken or visual) by itself. This result, along with the fact that there was such a close correspondence between children's understanding of spoken and visual ambiguity, suggests that children's performance would not be significantly different were their understanding of spoken ambiguity assessed following two messages rather than one. Consequently, the first possibility does not seem as likely as the second possibility - that the improved performance of children in this study reflects the simplified design which allowed them to demonstrate their understanding of an ambiguous message.

Regardless of which of these two arguments is correct our results provide clear evidence that children as young as 4 years of age are beginning to understand the fact that ambiguous perceptual cues are an insufficient source of knowledge.[2] The probability that an individual child would obtain the correct answer pattern (correctly attribute knowledge to the other in the two unambiguous conditions, yet attribute ignorance to the other in the two ambiguous conditions) by chance is about 0.06. Hence, these children almost certainly understood the way in which ambiguous perceptual information limits knowledge.

Overall, 18 of 32 children (56%) made correct assessments of the other's knowledge over the two ambiguous conditions of the present study. These children demonstrated a clear understanding that perceptual information is ordinarily a sufficient source of knowledge (when cues are unambiguous), and that perceptual information is sometimes an insufficient source of knowledge (when cues are ambiguous). Furthermore, the above figure (56% correct) is remarkably similar to children's performance in Ruffman et al.'s study (53% correct), where they also were required to assess the other's knowledge on two ambiguous conditions (same and opposite perspective). The results of this study along with those of Ruffman et al. suggest that age 4 is indeed the transitional age in children's understanding of the fact that perceptual information is sometimes an insufficient source of knowledge.

There was also a marked difference between the performance of subjects aged 4;1 to 4;5 (mean 4;3) and those aged 4;6 to 4;11 (mean 4;9). Whereas only 6 of 15 (40%) of the younger 4-year-olds were correct when assessing the other's knowledge over the spoken and visual ambiguous conditions, 12 of 17 (71%) of the older group were correct over these two conditions. Thus, it appears that by the second half of the fifth year of life, most children understand that perceptual information is sometimes an insufficient source of knowledge.

It could be argued that when the cues are made as salient as they were in this study children have essentially been given the answers to the questions and that this is, therefore, not a true test of their understanding of ambiguity. However, we would argue that there are two reasons for thinking otherwise. First, while the ambiguity task employed in the present study and in the study of Ruffman et al. (1989) did undoubtedly make things easier for children, we do not believe the results were distorted in an invalid manner. Instead, as we suggested earlier, such changes merely make these studies more comparable to false belief tasks where relevant cues have in the past been made more salient. Secondly, if we had given children the answers then more children should have passed these

tasks than was the case. Perhaps what is most significant is not that many 4-year-olds seem to understand ambiguity, but that more 3-year-olds (as Ruffman et al. (1989) showed) and 4-year-olds cannot solve these tasks despite efforts to make them as easy as possible. This result is consistent with that obtained by Moses and Flavell (1989) who made similar efforts to simplify a false belief task yet found that 3-year-olds still were not able to understand another's false belief. Clearly, these children are simply incapable of taking advantage of the relevant perceptual information when judging another's mental state. We would argue that they are unable to do so because they are incapable of metarepresentation.

Finally, our results in combination with those of earlier research suggest the following sequence in children's understanding of the relation between perception and knowledge:

1. For some time before they reach 3 years of age, children are likely consistently egocentric when assessing the knowledge of others. These children do not understand that perception ordinarily leads to knowledge and that an absence of perception leads to an absence of knowledge.

2. By 3 years of age or earlier, most children base their assessments of another's knowledge on the presence or absence of perceptual information (Pillow, 1989; Pratt & Bryant, 1988). They believe that access to perceptual information, even incomplete information, leads to knowledge and that an absence of perceptual information results in an absence of knowledge.

3. Around 4 years of age children begin to understand that perceptual information is sometimes an insufficient source of knowledge, in other words, that perception may be nonepistemic (Dretske, 1969). We believe that this recognition is tied to a nascent capacity for metarepresentation which is fundamental to their understanding of ambiguity (Ruffman et al., 1989, the present study), false belief (Perner et al., 1987), appearance-reality (Flavell et al., 1986), Level 2 perspective-taking (Flavell et al., 1981), and representational change (Gopnik & Astington, 1988).

4. By age 5, most children understand the conditions of knowing and have developed the capacity for metarepresentation. Specifically, they recognize that perception is sometimes an insufficient source of knowledge and in consequence may lead to a false belief

It may also be that the development of children's understanding of

inference parallels the progression outlined above. As suggested earlier, such a finding would not be surprising given that inference also requires an understanding of the relation between incomplete perceptual information and knowledge. We are currently examining this possibility.

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Notes

[1]It is recognized that there is probably no such thing as having access to *complete* perceptual information. Even when there are no barriers to our seeing something (eg. when a cup is placed directly in front of us on a table) we do not see all of it (eg. we do not see the back of the cup). However, this sort of unencumbered or direct perceptual access is at least less incomplete (more complete) than that which is available in ambiguity or inference tasks.

[2]Indeed, though we have provided possible explanations for the difference between our results and those of earlier research, our primary aim is not in pointing out the impact different procedures can have on results, but rather, is concerned with the finding that many children as young as age 4 do, in fact, understand ambiguity.

Table 1

Experimental questions

Visual Conditions - Self:

1. Do you *know* which box the elephant (chicken) is in?
2. (a) *How* do you know?, or, (b) *Why* don't you know?

Visual Conditions - Other:

1. Does John *know* which box the elephant (chicken) is in?
2. (a) *How* does he know?, or, (b) *Why* doesn't he know?

Spoken Conditions - Self:

1. Do you *know* which cupboard the chocolate is in?
2. (a) *How* do you know?, or, (b) *Why* don't you know?

Spoken Conditions - Other:

1. Does John *know* which cupboard the chocolate is in?
2. (a) *How* does he know?, or, (b) *Why* doesn't he know?

Table 2

Number of subjects making correct and incorrect assessments of the other's knowledge in ambiguous conditions

		Visual	
		Pass	Fail
Spoken	Pass	**18**	**1**
	Fail	**3**	**10**